2023
PhilRice R&D Highlights

CROP PROTECTION DIVISION

Philippine Rice Research Institute
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Contents

Crop Protection Division

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EXECUTIVE SUMMARY

The Division aimed to prevent yield loss so that abundant rice will be harvested. Specifically, CPD aimed to generate, develop and promote sustainable pest management strategies to help farmers improve their decision-making on pests. Pest management strategies should be ecosystem-based, promote ecological diversity, environment-friendly, safe, economical, sustainable, and compatible with other management options.

In 2023, the Division implemented four core-funded projects that all contributed to the development of effective and sound pest management strategies. First, is the disease and insect pest resistance evaluation and characterization in support of varietal improvement. With increasing awareness of the undesirable human and environmental effects of pesticide application, the development and deployment of resistant cultivars have been at the forefront of disease and insect pest management. Thus, host resistance against biotic stresses is one of the traits mainly considered in the varietal improvement program of PhilRice. Second, is understanding the ecology of current and emerging rice pests and their management strategies. A deep understanding of the biology and ecology of these pests, most especially the emerging pests, is paramount in developing and deploying effective pest management strategies. Third, is the optimization of plant-enhanced nanoparticles as a potential molluscicide to control invasive apple snails. This further evaluates the effectiveness of Balakat leaf extracts infused in nano-zeolite and its formulation into pellet form to control invasive apple snails. Lastly, is the development of a molecular detection tool for seed-borne pathogens. The efficient and early detection of these important pathogens is essential for early containment and control measures to be implemented.

CPD also pursued four extra-core and one externally funded projects, including (1) Monitoring the occurrence, host plant specificity, and management of the fall armyworm (Spodoptera frugiperda) in- and around-rice ecosystems in the Philippines; (2) Development of Innovation System for Climate-Smart Pest Management in Rice (CSPM), and (3) Simulation modeling of bacterial blight and blast epidemic (PhilRice- International Rice Research Institute [IRRI]).

CORE-FUNDED PROJECTS

CPD-231-000: Disease and insect pest resistance evaluation and characterization, and pest surveillance in support of varietal improvement

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In an intensive rice production system worldwide, pests are one of the significant factors limiting productivity and food security. Disease and insect pest resistance is one of the traits mainly considered in the varietal improvement program of PhilRice. Screening and evaluation of breeding lines as well as uncharacterized rice germplasm at our Genebank against major rice diseases and insect pests are paramount to its breeding program. This ensures that varieties being developed by PhilRice have the necessary resistance/tolerance against major rice diseases and insect pests. Rice blast (Pyricularia oryzae), bacterial leaf blight (Xanthomonas oryzae pv. oryzae), sheath blight (Rhizoctonia solani), and rice tungro virus have caused significant yield losses in major rice-growing areas in the country. Planthoppers, leafhoppers, and stem borers pose a real threat.

In-depth resistance characterization of our germplasm ensures the variation of effective and functional disease and insect resistance genes (R genes) being utilized in our breeding program. Characterizing and identifying the mechanisms of host resistance facilitate the manipulation, effective transfer of genes to popular varieties, and eventual deployment of pest-resistant cultivars.

There were 1,268 breeding lines evaluated for resistance to sheath blight (ShB), bacterial leaf blight (BLB), tungro, and rice blast (RB) diseases, and brown planthopper (BPH), green leafhopper (GLH), and stem borer (SB) insect pests. We found that 816 entries were leaf blast- resistant, 56 were resistant to BLB, 9 were resistant to ShB, but none was tungro-resistant. All evaluated rice lines were not resistant to BPH and GLH; 99 entries showed resistant deadheart (DH) reaction against SB and 84 to whitehead (WH) damage. Rice blast resistance genes (Pi gene) present among 59 released varieties were estimated by comparing their disease reaction patterns with those of rice blast differential varieties. Eight varieties belonging to VG1 have shown resistant reactions to all of the 20 differential blast isolates. Using Pi gene-specific DNA markers, Pib gene was detected in 63% of the evaluated varieties, followed by Pik and alleles (36%), Pia (28%) and Pi2/9/zt (8%). Pish and Pii genes were not detected in any of the varieties.

Nine species of rice pathogens are currently at the microbial collection of the Plant Pathology Laboratory, including four new collections of pathogens Ustilaginoidea virens (rice false smut), Cercospora oryzae (narrow brown spot), Sarocladium oryzae (sheath rot), and Bipolaris oryzae (Brown Spot). Twelve isolates of U. virens, 5 isolates of C. oryzae, 3 isolates of S. oryzae, and 6 isolates of B. oryzae were successfully purified and stored. In addition to the existing collection, 56 rice blast, 3 sheath blight, 15 bacterial leaf blight, and 8 bacterial leaf streak were purified and stored.

Nine varieties and a donor line were evaluated for their mechanisms of resistance against BPH where NSIC Rc 222, Rc 402 and Rc 438 showed tolerance. For the SB rearing protocol, two methods were used: (1) collecting egg masses from the field and allowing them to emerge and crawl inside the leaf sheath and (2) collecting moths for egg-laying. Some 465 eggmasses collected from the field reached the 3rd generation but moths did not produce healthy eggmasses.

CPD-232-000: Ecology and management strategies for current and emerging rice pests

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The project aimed to determine the ecology of and develop management strategies for current and emerging pests in rice production. Specifically, it aimed to (1) reinforce our management options for high populations of rice yellow stem borer (YSB) and rice planthopper (RPH); (2) identify efficient strategies that can minimize the presence of weedy rice (WR) in rice transplanted areas; (3) develop location-specific nature-based solutions to fall armyworm (FAW) pest management/decision guide in managing the FAW in rice; (4) develop and further improve rice pest management techniques through a digital platform; and (5) quantify yield losses to rice blast and rice black bug in field conditions.

More stem borer egg masses were recorded at 5 to 9 weeks after transplanting (WAT). Highest eggmass count (3.75) was recorded at 9 WAT. Low egg parasitism at 6 WAT grew (41.11%) starting at 7 WAT. Tetrastichus contributed the highest egg parasitism (21.36%), followed by Telenomus (8.53%) and Trichogramma (4.26%).

Weedy rice in transplanted areas: a survey/farmers' interview were conducted in May 2023 in Sariaya, Quezon. Most of the farmers believed that the weedy rice problem will worsen if seeds are exchanged with other rice farmers. Farmers did not believe that a high seeding rate would reduce weedy rice. Most farmers believed that weedy rice was brought to their farms through mixed seeds. On the other hand, a mechanical weeder was evaluated for its performance in controlling weeds. It could weed 1-1.5 ha/day, at 77% efficiency and without damaged plants. Results showed that the use of pre-emergence herbicide (2 Days after Transplanting(DAT)) followed by (fb) mechanical weeder (25 DAT) produced the least total weed density and biomass in both trials/seasons compared to other treatments. Application of post-emergence herbicide (15 DAT) and fb mechanical weeder (25 DAT) had the highest return on investment (ROI) in both trials.

In addition to the recurrent invasions (2021-2023: May-June) of FAW in Gonzaga and Santa Ana, Cagayan in 2023, FAW sightings were documented in rice seedlings at seedbed in San Jose City, Nueva Ecija in July 2023 (1st invasion was June 2022); first occurrence in Maligaya, Science City of Muñoz (July 2023); and in Bontoc, Mountain Province (September 2023); and also, first occurrence on dry season establishment (October 2023) in Santa Ana, Cagayan. One grass (Leptochloa chinensis), one sedge (Cyperus iria), and three broadleaves: Cleome rutidosperma, Hedyotis corymbosa and Ludwigia hyssopifolia were evaluated for suitability as alternate hosts of FAW through feeding and oviposition preferences. FAW fed on and laid eggs on the sedge and the grass first. Then if fed on all weed species screened, which could possibly serve as larval hosts in the absence of its primary hosts.

A prototype of a computer system that can identify and count three major insect pests was generated. For the improvement of the e-damuhan app, one data set containing more than 1,000 clear leaf images of 47 weed species were gathered. A weed control matrix was also updated for real-time recommendation. To quantify yield losses to rice blast, model development field experiments were carried out by assessing leaf blast severity and neck blast incidence in NSIC Rc 402 variety. During the vegetative stage, low incidence and severity of leaf blast was observed ranging from 2 to 5%. At maturity stage, neck/panicle blast incidence ranged from 8 to 14%, indicating that the disease did not progress due to other factors.

CPD-233-000: Product development and evaluation of Balakat [Ziziphus talanai (Blanco)] Merrill] nano-molluscicide against invasive apple snails Pomacea canaliculata (Lamarck) in direct-seeded rice

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In a recently concluded project by Bagunu, et al. 2022, funded by PhilRice under Phase 1 of the nano-molluscicide project, it was established that Z. talanai leaf extracts infused in Nano-Zeolite yielded the best results at 600 ppm Z. talanai in combination with Zeolite as compared with the Neem and Makabuhay samples tested in affecting the inactivity and mortality of the invasive apple snails. Increasing the NanoZeolite concentration to 400 ppm also yielded promising results.

At the second phase of project implementation, the best combinations of nano-zeolite and Z. talanai extract concentrations against the snails in the laboratory were optimized. The extracts were freeze-dried before being mixed with the nanozeolite and formulated into pellet form, which was optimized as well.

A trial production of Z. talanai pellets using a portable pelletizer was undertaken to determine their quality. A tray trial experiment on the molluscicidal activity of Z. talanai-nano molluscicide pellets against invasive apple snails was conducted to simulate their natural setting under laboratory conditions.

Snail inactivity, mortality, and percentage of consumed seedlings were observed every twelve hours after treatment application for three days. Results showed that only the positive control obtained a mortality rate (100% was observed at the 48-hour mark). For snail inactivity, snails in the T+ were inactive (dead) followed by T1 (pure nanozeolite). However, T5 (600ppm nanomolluscicide pellets) and T6 (800ppm nanomolluscicide pellets) obtained the lowest % consumed seedlings among the treatments.

CPD-234-000: Development of the improved isothermal amplification-based biosensor against the seed-borne pathogens of brown spot and sheath rot of rice

Rubigilda Paraguison-Alili, Jennifer T. Niones, and Jonalyn J. Noveno

This project wants to develop improved DNA amplification-based biosensors for detecting brown spot and sheath rot. As a precursor in developing effective molecular assays for disease detection, DNA markers were designed based on specific genes of interest related to the target pathogens. PCR and Loop-mediated Isothermal Amplification (LAMP) primers were developed, providing a reliable method for their identification. Routine assays were conducted for PCR optimization and LAMP-RPA. PCR amplification of the target region using the designed primers ensures its specificity and effectivity before proceeding to LAMP-RPA assay. Moreover, LAMP-RPA optimization including specificity and sensitivity tests were performed for Bipolaris oryzae. On the other hand, positive control for Sarocladium oryzae was synthesized for PCR optimization and LAMP-RPA assay.

EXTRA-CORE PROJECTS

Project 1: Monitoring the Occurrence, Host Plant Specificity, and Management of the Fall Armyworm (Spodoptera frugiperda) in-and around-Rice Ecosystems in the Philippines

Evelyn M. Valdez, Genaro S. Rillon, Dindo King M. Donayre, Edwin C. Martin, Eduardo Jimmy P. Quilang, Kennedy B. Dela Cruz, and Ravindra C. Joshi

FAW, a transboundary invasive pest in many countries, is threatening the food, nutrition, and income security of millions of farming households. Native to the tropical regions of North and South America, it was first detected in early 2016 in the rainforest zones of Central and Western Africa. Since then, FAW has been reported in almost all sub-Saharan African countries and is currently observed to be invading South and Southeast Asia. FAW is an invasive pest of corn as was first reported on June 20, 2019 in Piat, Cagayan. It has now spread to all regions.

Little is known about FAW damage and host preference for rice. The project aimed to contribute in developing location-specific integrated FAW management strategies. Specifically: (a) monitor the presence of FAW in- and -around rice ecosystems and identify areas where it was observed; (b) assess the level of infestation and its damage; (c) determine the diversity of naturally occurring beneficial organisms; (d) identify the alternate host plants of FAW; and (e) enhance the knowledge and capacity of local researchers and extension workers in using CABI knowledge tools for better FAW risk analysis and management.

Regular monitoring of FAW and vegetation analysis were conducted in rice-corn growing areas in Pangasinan, Tarlac, and Pampanga from 2021 to 2022 dry and wet seasons. The project also monitored the possible occurrence of FAW and its damage on rice and identified its alternate host plants.

As the project concluded, targets were met based on the specific objectives: (a) no FAW or its damage on rice was recorded, although FAW on rice was documented on May 17, 2021 in Pateng, Gonzaga, Cagayan. Subsequently, it was recorded in 13 other municipalities in Region 2. There was a re-invasion on May 24, 2022 in Flourishing, Gonzaga and in 8 and one other barangays of Gonzaga and Santa Ana, respectively. The first FAW infestation in Region 3 was reported in Porais, San Jose City, Nueva Ecija on June 24, 2022. Based on the DNA Barcoding conducted by CABI-UK, both the C-strain and R-strain were found in the Philippines. Further, some FAW larvae collected from the rice monitoring sites were found to be C-strain while some of those collected from corn were R-strain, suggesting the existence of a mixture of these two strains in both ecosystems.

As to the other objectives, (b) the DA-Regional Crop Protection Center 2 reported FAW infestation on rice seedlings in 94.714ha with 2–22% damage that started in Gonzaga on May 17, 2021. We recorded 276 FAW larvae/m2 in the remaining infested seedbeds of varieties NSIC Rc222, and 32 larvae/m2 in Longping 2096. During its re-invasion in 2022, the recorded FAW population and damage on rice seedbeds were 19.33 – 20.8 larvae/m2 with 1.2% damage and 3.33 – 8.67 larvae/m2 with 7.12% damage on inbred and hybrid varieties, respectively; (c) two parasitoids, Brachymeria lasus (Hymenoptera: Chalcididae) and Copidosoma floridanum (Hymenoptera: Encyrtidae) emerged from the field-collected FAW larvae reared in the laboratory. Both parasitoids are new records on FAW in the Philippines and elsewhere; (d) vegetation and potential host plant analysis from the rice-corn growing areas recorded 70 weed species that could serve as alternate host plant of FAW. Among the dominant weed species, FAW preferred to feed and lay their eggs on Dactyloctenium aegyptium (DTTAE), Digitaria ciliaris (DIGCI) and Eleusine indica (ELEIN); and (e) the CABI provided two trainings/webinars to enhance the knowledge and capacity of local researchers and extension workers in DA agencies on FAW diagnostics, ecology and management; and the risk factors for invasion, dispersal, and migration to better understand and manage FAW.

Project 2: Development of Innovation System for Climate-Smart Pest Management in Rice (CSPM) – PhilRice Component

Dindo King M. Donayre, Jennifer T. Niones, Alona Grospe, and Anna Marie S. Irang

Filipino rice farmers face the adverse effects of climate change, which will increase the frequency of typhoons, floods, droughts, and water shortages. It may even increase the risk of certain pests at different spatiotemporal scales. As climate changes, conditions affecting pest outbreaks or disease epidemics may shift in space and time, favor invasive species, alter the populations of insect pests and pathogens, and may reduce the effectiveness of existing pest management strategies and tactics. Implementation of climate-smart rice cultivation practices will therefore be insufficient if proactive strategies for pest management are not considered.

This project therefore aimed to reduce crop losses caused by pests, enhance ecosystem services, and reduce greenhouse gas emissions by developing an innovation system for the scaling of CSPM. It also aims to provide the DA and various stakeholders with data and evidence-based information to make informed decisions and set policies related to CSPM.

PhilRice is directly involved in the characterization of the population structure of bacterial blight and rice blast pathogens in rice-growing areas; and in testing the efficacy and improving the efficiency of biological control agents (BCAs). Bacterial blight-infected leaf samples were collected in Cagayan, Isabela, Nueva Ecija, Iloilo, Antique, Samar, Leyte, and Agusan del Sur/Norte. These were processed and 376 samples were sent to Intertek, Sweden for genotyping. For the work on BCA, the efficacy of Trichoderma harzianum against the sheath blight pathogen of rice was evaluated under laboratory and rainfed conditions.

EXTERNALLY FUNDED PROJECT

Project 1: Simulation Modeling of Bacterial blight and Rice Blast epidemic (PhilRice- IRRI)

Leonardo V. Marquez, Edwin C. Martin, Maria Salome V. Duca, Eduardo Jimmy P. Quilang, and Nancy Castilla

Among the local major diseases of rice, bacterial leaf blight (BLB) and rice blast are the most prevalent both in dry and wet cropping seasons. Yield loss in BLB is about 70%; rice blast is 50-85%. Simulation models to predict yield losses involved the collection of epidemiological parameters important to disease development.

The PhilRice component of the project involved weekly collection of BLB and blast incidence and severity in susceptible lines and varieties. Moreover, the incubation latent and infectious period of BLB in susceptible variety, IR24, was determined.